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THE DIVISION OF MILITARY AIR TRANSPORTATION BETWEEN CIVILIAN AN--ETC(U)

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6 THE DIVISION OF MILITARY AIR TRANSPORTATION BETWEEN CIVILIAN AND MILITARY CARRIERS

10 L. J. Kleiger

14 RAND/RM-5924-PR

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ABSTRACT

PREFACE

This ~~RAND-initiated~~ study examines some of the issues involved in dividing military air transportation between military and civilian air carriers. In the course of this research, it was found that a definitive statement about the desired level of commercial augmentation must await the development of better theory and a more comprehensive collection of the applicable data. Therefore, this first look at the subject focuses on setting up a framework within which the relevant issues and pertinent analytical procedures become apparent, thus helping the decisionmakers involved to organize the issues. Further, it presents a cost analysis that shows the currently available methods for carrying out the analysis indicated through the framework. Both parts of the study provide points of departure for future research and articulate a demand for the data and research that will lead to a policy statement covering carriage of military traffic by civilian air carriers.

ABSTRACT

A

SUMMARY

For many years, the Department of Defense, the commercial airlines of the United States, and the Congress have debated about the level of airline participation in military traffic during peace and war. The problem is this: The Military Airlift Command (MAC), like other Government agencies, is charged with promulgating policies that will help develop commercial air transportation; however, it must also consider its war mission and peacetime training requirements. MAC's critics argue that if MAC carries more traffic than required to support the latter, it is an "airline" competing with commercial carriers. MAC argues that if a large commercial augmentation program limits it to a daily aircraft utilization that is too small to keep its personnel trained, then MAC has insufficient wartime capability. So far, this difference has been resolved politically by appeal to Congress with little accompanying analysis. Analytic statements have been confused with statements based on the preferences of those who can exercise some control over how much commercial airlift is used. Further, the discussions have skirted a fundamental issue: What is the Government trying to accomplish with commercial augmentation and what constraints limit commercial use?

This research was undertaken with three objectives in mind: to provide a framework for investigating the desired level of commercial augmentation by setting out the constraints and criteria involved; to inquire about the nature of the constraints; and to illustrate the currently available means for determining the cost of those constraints based on preferences. If the constraints are based on preferences rather than physical limitations, it becomes important to look at their cost because preferences can prevent the choice of a feasible least-cost way of providing airlift to the military. Once this is done, the agencies that make decisions about commercial augmentation will have an idea of how high their subjective valuation should be to warrant keeping the constraints.

Commercial augmentation has been placed under numerous constraints. They range from a floor under prices for the airlines' services to re-

strictions on the type of goods the airlines can carry. Some constraints, such as limitations on area of operation, apply to the military as well as to the airlines. Several criteria have been suggested for choosing among alternative ways of furnishing air transportation to the Services. We have focused on cost minimization for a given amount of airlift.

From the various constraints on the program, we consider the one that limits the type of goods the airlines may carry to "civil eligible requirements." Evidence available from data on the type of commodities that MAC ships on channel routes and from new data on special assignment airlift missions (SAAMs) suggests that this constraint is based on preferences rather than on actual physical limitations on the type of services the airlines can perform.

The special handling required by MAC cargo consists of refrigeration and the special packaging and labeling demanded by dangerous articles. The airlines have shipped both kinds of goods. Cargo outsize because of length presents something of a problem for the airlines because none of their planes have end-loading capability. However, there is no reason to believe that the airlines could not purchase an aircraft to accommodate such cargo if they believed it profitable. We used Transportation Control and Movement Document data to show the type of goods shipped in scheduled operations, and we processed unpublished SAAM data collected by MAC to show the type of goods shipped in unscheduled operations.

To measure the cost of the civil eligible constraint, we used two models to compare alternatives that would be competing if the constraint were not in operation. We examined airline and military costs of the purchase and operation of fifty-seven C-5A aircraft that represent a hypothetical addition to a previously acquired MAC C-5A fleet. Unfortunately, the costs generated are not usable. Although cost models among the best that research has provided were used, they turn out to be incommensurate and could not assess the cost of the constraint. However, this effort produced some notions of the pitfalls to avoid in designing two comparable models for measuring differences in military and civilian air transport operations.

Research into the construction of one model that measures the costs of both operations may also be fruitful if evidence shows that insti-

tutional factors such as the draft are more important in explaining differences between commercial and military operations than technological factors such as different production functions. Other areas for research include acquisition of time series data on cargo characteristics of MAC cargo shipments and some consideration of the goals of the commercial augmentation program with attention to how they interact with other military goals.

Before a definitive statement can be made about the level of commercial augmentation, the data and theory called for must be acquired. Without these data and without a theoretical basis for comparing the cost of alternative ways of furnishing military airlift, definitive analysis of the desired level of commercial augmentation must be limited to setting forth a framework and making recommendations for future research.

ACKNOWLEDGMENTS

I am greatly indebted to members of the Military Airlift Command for supplying much of the data and information used in this study.

I am also indebted to personnel of the Boeing Company, Seattle, Washington, who provided data for Section V of the study and reviewed a draft of that section. They have advised us, however, that Boeing would have used a different approach and assumptions in the treatment of this section, and therefore cannot concur with its conclusions.

Thanks are also due to I. N. Fisher, D. M. Fort, G. R. Hall, D. F. Loveday, R. M. Paulson, and Captain H. L. Green of The RAND Corporation for valuable suggestions.

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I. INTRODUCTION

Since the end of the Second World War, the military has augmented its own airlift resources by purchasing transportation services from the commercial airlines of the United States. The airlines have transported cargo and passengers throughout short-term emergencies such as the Cuban Crisis as well as during sustained conflicts such as the Vietnam War. They have also supported our troops in routine peacetime operations. Over the years this source of business has been profitable enough to cause the airlines to seek its increase. They have pressed the case for larger commercial augmentation of military airlift both to the Department of Defense and before various congressional committees. Their trade association, the Air Transport Association of America, has been a vocal spokesman. The Department of Defense has not always agreed that commercial augmentation ought to be expanded, so the debate has been lively. This Memorandum examines the issues relevant in choosing the mix of commercial and military air carriers to handle military traffic in peace and war.

In view of the confusion of statements based on preferences with statements stemming from analysis that has prevailed in these debates, the first object of this study is to improve the framework for analysis of the program. It sets out the constraints that limit the type and amount of airlift that the civilian air carriers can offer to the military and the criteria that enable the analyst to choose among alternative ways of providing airlift to the military.

The second goal is to evaluate the constraint that limits the type of military traffic available to the airlines to "civil eligible requirements." This is one of the most restrictive and therefore one of the most important of the constraints. Some restrictions reflect physical limitations; some merely the preferences of agencies that have some control over the program. According to the criterion adopted here, the latter can prevent the best choice if it precludes from consideration the cheapest feasible alternative way of providing military airlift. We recognize, however, that other criteria may be relevant. For example, in order to maximize their utility, those who control commercial aug-

mentation may wish to override this criterion when the value they place on the constraint is higher than the cost it places on the operation. We attempt to evaluate the constraint by placing it either in the category of preferences or physical limitations and by asking whether it does prevent the consideration of cheaper alternatives.

To indicate the importance of commercial augmentation to the military and to the airlines, Sec. II presents some background material on the program. In the third section, the constraints that limit the program are delineated and various criteria are discussed. Section IV looks at the basis for the "civil eligible" limitation. The data used to indicate the type of cargo airlift demanded by military customers are limited in the time they cover, but do reflect demand in those areas of military airlift that are not purely military in nature. The fifth section presents the results of a cost analysis that illustrates the currently available means for determining whether policies such as the civil eligible constraint do impose a cost to the military. Section VI summarizes the issues relevant to formulating the desired size for commercial augmentation. Two appendixes present the detailed data used in the study. The Appendix that follows Sec. VI displays the cost models and model inputs used in Sec. V. Another Appendix, published under separate cover because it is classified, exhibits data on cargo airlift demand pertaining to special assignment airlift missions of the Military Airlift Command.

II. BACKGROUND

THE IMPORTANCE OF THE COMMERCIAL AUGMENTATION PROGRAM

To show the importance of commercial augmentation to the airlines and the military, this section examines the airlines that have participated in the program, their dependence on military business, and the part civilian carriers play in military air transportation.

The Civil Aeronautics Board (CAB), which regulates U.S. air transportation, has certified several classes of airlines to provide transportation within the continental United States and to foreign countries. The trunklines, such as United, TWA, and American, may carry passengers and cargo on scheduled and charter flights. The local service carriers such as Air West and Mohawk, and the Alaskan and Hawaiian carriers, provide the same kind of transportation as the trunks except that their area of operation is supposed to be limited to a particular region. For the local service carriers, this distinction has become blurred over the years so that now the best way to define both the trunks and the local service carriers is to name the airlines in each class. The all-cargo lines, such as Flying Tigers, carry cargo on scheduled runs and passengers only on charter flights. Trans International, World, and the other supplemental airlines are limited to the carriage of both passengers and cargo on charter flights.*

The trunklines, all-cargo and supplemental carriers supply most of the commercial augmentation services. From the inception of the augmentation program, the supplementals and the all-cargo carriers were dependent on military sales for a larger percentage of their business than the trunks. The latter, as a group, have never participated very strongly in the program, although as we shall see, several individual trunklines have received large contracts. Table 1 shows that a

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*The trunklines include American, Braniff, Continental, Delta, Eastern, National, Northeast, Northwest, United, TWA, and Western. Airlift International, Flying Tigers, and Seaboard World are the presently active all-cargo carriers. Thirty-five supplemental airlines have done business with the military since 1955. The major ones have been Capitol, Overseas National, Saturn, Trans International, World, and Zantop.

very small amount of trunkline revenue ton-miles, both in passenger and cargo service, comes from military sales. In contrast, most of the revenue ton-miles accumulated by the supplementals in cargo operations was generated outside the civilian segment of the economy.

Table 1

PERCENT OF AIRLINE REVENUE TON-MILES DERIVED FROM MILITARY SALES -- SELECTED YEARS

Type of Operation	1961	1962	1964	1966
Trunklines[a]				
Cargo	0.5	0.8	1.4	8.0
Passengers	2.1	2.3	2.5	7.6
All-Cargo				
Cargo	59.4	70.0	43.5	61.9
Passengers	88.5	88.2	67.0	90.1
Supplementals				
Cargo	95.4	89.6	86.2	87.4
Passengers[b]	41.7	56.3	64.3	62.3

SOURCES: U.S. Civil Aeronautics Board, Bureau of Accounts and Statistics, Air Carrier Analytical Charts and Summaries, various issues; ibid., Handbook of Airline Statistics, various issues.

[a]Includes Pan American, which is generally classed as an international carrier.

[b]Percentage based on revenue passenger-miles rather than revenue passenger ton-miles.

Passenger operations also depend heavily on military sales. Except for 1961, over 50 percent of their passenger revenue ton-miles came from this source. As one would expect, the all-cargo lines' dependence on military traffic is heaviest in the passenger field, but in the 1960s such traffic also comprised a substantial portion of cargo revenues.

Military traffic carried between the continental United States and foreign points on a scheduled, fixed-route operation accounts for most of the military transportation allowed to the airlines. This is called channel traffic and will serve to measure airline participation in military transportation. Table 2 shows that airlines have been moving a

growing percentage of military passengers. Nearly all military passengers have been transported on commercial lines in the years of the Vietnam buildup. On the other hand, the military has carried most of its own cargo, although the airlines have increased the percentage carried over the early days of the program.

Table 2

PERCENTAGE OF CHANNEL TRAFFIC CARRIED BY AIRLINES[a]

Fiscal Year	Revenue Passengers	Cargo/Mail
1959	39.1	12.7
1960	43.2	10.4
1961	41.4	16.5
1962	56.3	40.5
1963	66.4	37.5
1964	67.9	22.2
1965	72.5	26.1
1966	89.5	30.2
1967	90.8	33.7
1968[b]	91.0	25.6

SOURCES: USAF, Military Airlift Command, <u>Airlift Service Management Report</u>, 1959-1967; ibid., <u>Quarterly Narrative Report, Single Manager for Airlift</u>, May 1967, November 1967, and February 1968 (xerox).

[a]The percentages are based on number of revenue passengers and tons of cargo and mail.

[b]First three quarters.

Table 3 presents two additional characteristics of channel traffic. First, the amount spent on it has increased substantially. Channel traffic contracts have increased in value from a little over $5½ million in 1955 (the first year for which published data are available) to almost $600 million in 1967. The rate of increase was fairly gradual until 1964, when it rose markedly. Figure 1 shows the striking effect of Vietnam on commercial augmentation. Second, the type of participating air carrier has changed. In the last few years, the trunklines have shown an interest that they previously lacked in carrying military

traffic. The supplemental, all-cargo and Part 45 carriers* have been receiving a steadily decreasing percentage of the contracts. In spite of this, since trunkline revenue from other sources has also been rising, military revenues still account for a small percentage of total revenue for these airlines. Table 1 shows, for example, that in 1966, even

Table 3

COMMERCIAL AIRLIFT: CHANNEL TRAFFIC
(In $ thousand)

Fiscal Year	Trunklines[a]		Supplemental, All-Cargo, and Part 45 Carriers		Total
	Amount	Percent	Amount	Percent	
1955	589	10.4	5,053	89.6	5,642
1956	15,495	36.1	27,422	63.9	42,917
1957	11,049	22.2	38,698	77.8	49,747
1958	8,375	14.8	48,387	85.2	56,762
1959	19,015	27.2	50,802	72.8	69,817
1960	5,828	9.1	58,364	90.9	64,192
1961	20,197	25.5	58,998	74.5	79,195
1962	42,472	29.9	99,416	70.1	141,888
1963	55,254	33.2	111,191	66.8	166,445
1964	50,764	35.2	93,257	64.8	144,021
1965	87,326	45.0	106,630	55.0	193,956
1966	156,253	47.7	171,630	52.3	327,883
1967	328,441	55.0	269,132	45.0	597,573
1968[b]	310,838	63.8	176,494	36.2	487,312

SOURCES: U.S. Congress, House, Committee on Armed Services, Military Airlift, Hearings before a Special Subcommittee on National Military Airlift, 86th Congress, 2d Session, 1960, p. 4564; ibid., Military Airlift, Report of the Special Committee on National Military Airlift, 89th Congress, 2d Session, 1966, pp. 7216-7217; U.S. Air Force, Military Airlift Command, Procurement Committee, Commercial Airlift Dollar Obligation, fiscal years 1966, 1967, 1968 (xerox).

[a]Includes Pan American.

[b]Total for fiscal year 1968 estimated as of 30 September 1967.

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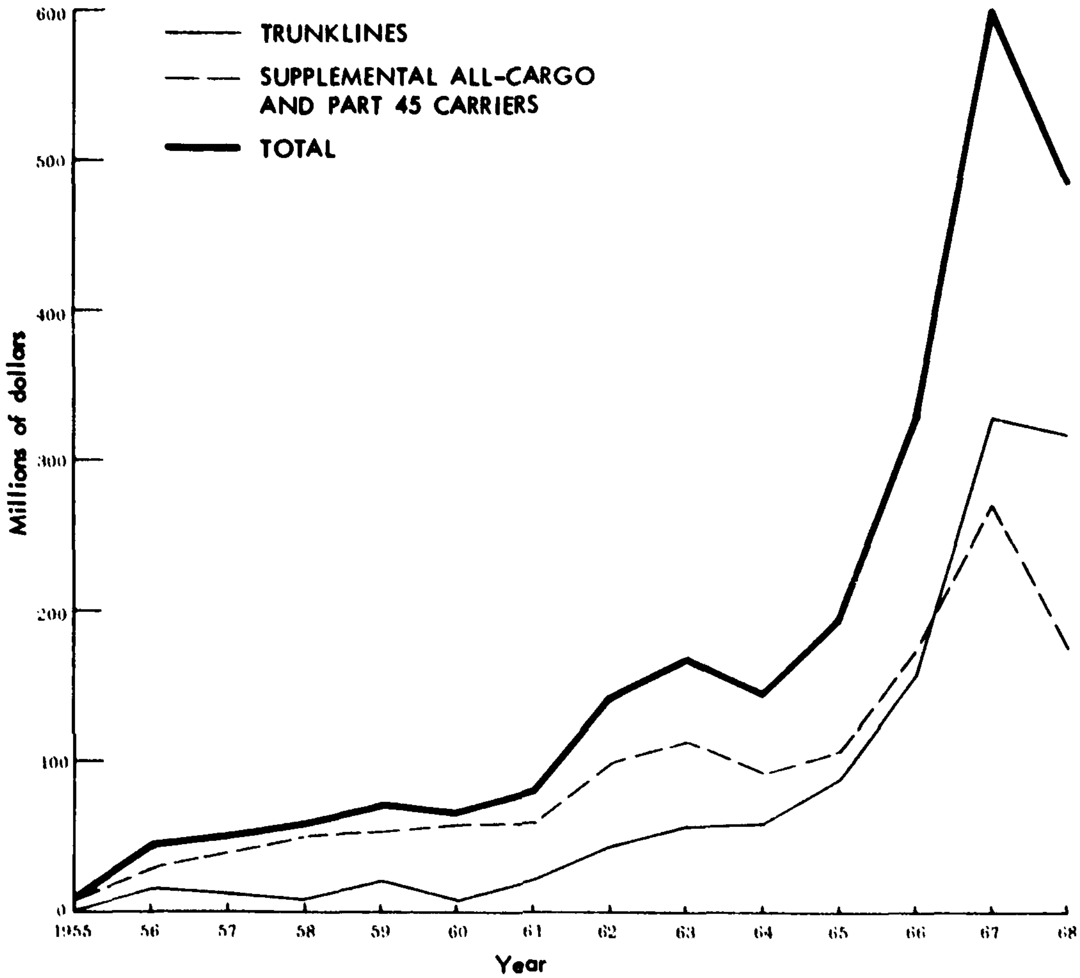
*Part 45 carriers were those which operated on a private for-hire basis as opposed to a public air carrier. These operators had commercial operator certificates issued by the Federal Aviation Agency pursuant to Part 45 of the Civil Air Regulations.



SOURCE: Table 3.

Fig. 1 -- Commercial airlift--channel traffic

though the trunks received almost 50 percent of the dollar value of channel traffic contracts, this revenue still amounted to only 8 percent of their total cargo and 7.6 percent of their total passenger revenue ton-miles.

There is one exception to the generalization that the trunkline carriers do not depend very heavily on military revenue. Continental Airlines has recently become a large contractor for the military, devoting a sizeable amount of its capacity to Department of Defense work. Almost 47 percent of its passenger revenue ton-miles and almost 66 percent of its cargo revenue ton-miles for 1966 came from military sales.

Military sales are something new for Continental, as Table 4 indicates; its first contract was for fiscal 1965. Pan American, TWA, and Northwest have been large contractors for many years. Pan American has held the largest augmentation contract each year since 1962. In contrast to Continental, however, Pan American's military revenues accounted for only 13.3 percent of its passenger revenue ton-miles and 0.5 percent of its cargo revenue ton-miles in 1966. Comparable figures for Northwest and TWA are 25.6 and 17.0, and 7.4 and 5.3, respectively.

CONTROVERSY OVER THE LEVEL OF COMMERCIAL AUGMENTATION

Many of the United States airlines have relied heavily on military contracts for their livelihood; at least during the early years of the commercial augmentation program, civilian markets to which government regulations permit access have been quite small, and there is evidence that they would not have supported carriers wholly dependent upon them. In the last few years, the charter and cargo markets have grown considerably, but they are still limited when compared to the potentials offered by access to military traffic. Recently, the trunklines have joined the program in a substantial way; apparently the profitability of military sales compares favorably with the rate of return available in civilian markets. Thus, it has been worthwhile for all of the different classes of airlines to spend the time and money to try to convince Congress to increase airline participation in military transportation, after finding the military establishment to be less than enthusiastic about this idea. Both singly and through their trade association, the airlines have argued before Congress that the military air carrier, the Military Airlift Command (MAC), was conducting airline-type operations in direct contravention of various Congressional statements advising government agencies to refrain from competing with the civilian sector of the economy.*

*Two acts of Congress carry this message. The Transportation Act of 1940 declares the aim of Congress with respect to transportation to be the promotion of all forms of transportation to meet the "need" of the commerce of the United States, the Post Office and the national defense. The Federal Aviation Act of 1958 voices the same sentiment.

Table 4

MILITARY REVENUE OF SELECTED AIRLINES:[a] CHANNEL TRAFFIC
(In $ thousand)

Carrier	1955[b]	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968[c]
Airlift International	--	--	--	--	--	--	3,692	13,080	9,232	6,093	9,675	19,161	57,168	27,668
Continental Airlines	--	--	--	--	--	--	--	--	--	--	13,273	37,253	65,824	57,770
The Flying Tiger Line	1,535	3,024	6,539	19,034	18,996	8,285	13,812	30,667	32,098	24,526	29,830	41,178	71,073	40,514
Northwest Airlines	--	555	461	80	398	17	880	2,747	3,352	10,584	17,172	37,050	50,174	41,632
Overseas National Airways	534	3,016	400	3,443	20,114	11,234	5,464	3,207	123	--	--	21	7,264	4,610
Pan American Airways	236	3,823	5,294	4,553	6,776	2,358	13,433	33,411	39,594	26,739	35,846	46,712	94,764	86,186
Seaboard World Airlines	427	10,117	10,256	11,896	5,348	4,922	5,385	10,525	13,813	14,104	17,448	29,168	32,536	25,743
Slick Airways	302	4,266	8,459	7,072	6,601	7,981	8,062	10,611	12,133	11,416	11,628	18,567	--	--
Trans International Airlines	--	--	--	--	--	1,841	1,233	6,117	11,708	9,591	9,236	18,100	14,881	14,467
Trans World Airlines	--	333	514	1,418	9,649	420	3,480	4,710	4,588	5,152	11,498	17,938	34,435	33,531
World Airways	--	--	1,369	2,347	626	118	6,609	10,136	15,660	16,857	18,143	24,714	38,131	37,513

SOURCES: U.S. Congress, House, Committee on Armed Services, Military Airlift, Hearings before a Special Subcommittee on National Military Airlift, 86th Congress 2d Session, 1960, p. 4564; ibid., Military Airlift, Report of the Special Committee on National Military Airlift, 89th Congress, 2d Session, 1966, pp. 7216-7217; U.S. Air Force, Military Airlift Command, Procurement Committee, Commercial Airlift Dollar Obligation, fiscal years 1966, 1967, 1968 (Xerox).

[a]These airlines are the largest contractors.

[b]All years are fiscal years.

[c]Contracts let as of 30 September 1967.

Because such lobbying has achieved some measure of success, it has become an area of concern to the Military Airlift Command. Several times, Congress has admonished MAC to give more business to the commercial lines. In 1956, The House Appropriations Committee called the Military Air Transport Service (MATS), as the Military Airlift Command was then named, "on the carpet" for its continuous resistence to recommendations made by the Air Coordinating Committee and the Second Hoover Commission to increase commercial airline participation in the carriage of military traffic.* The Senate report accompanying the Department of Defense Appropriation Bill for 1958 called for the civilian carriers to transport 40 percent of the passenger and 20 percent of the cargo portions of MATS requirements. The repercussions of the criticism of the "airline-type activities of MATS" grew beyond verbal reprimands in 1960 when Congress refused the Air Force appropriation for an initial purchase of 10 jet aircraft.

In this same year, the airlines won agreement from the Department of Defense to reduce military airlift of channel traffic. The DOD report, The Role of MATS In Peace and War, recommended that "MATS routine channel traffic . . . operations be reduced on an orderly basis, consistent with assured commercial airlift capability at reasonable cost, and consistent with economical and efficient use, including realistic training of . . . MATS capacity . . ."**

This report reiterated the military side of the controversy that had been posited before Congress during the hearings on military airlift: commercial augmentation affects MAC's ability to carry out the role of military air transportation during wartime. The Military Airlift Command is charged with "maintaining and operating a military system designed to assure an adequate emergency readiness position . . ."***

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*U.S. Congress, House, Committee on Appropriations, Department of Defense Appropriations for 1959, Hearings before Subcommittee, 85th Congress, 2d Session, U.S. Government Printing Office, Washington, D.C., 1958, p. 886.

**U.S. Congress, Senate, Committee on Appropriations, Department of Defense Appropriations for 1961, Hearings before Subcommittee, 86th Congress, 2d Session, 1960, p. 803.

***U.S. Air Force, Military Airlift Command, Airlift Service Management Report, Scott Air Force Base, Illinois, July 1966-June 1967, p. 6.

This means that MAC's size and the type of operations it conducts are dictated by the Joint Chiefs of Staff (JCS) approved wartime airlift requirements. According to the military, these requirements can be divided into those that only military aircraft can handle and those that can be met with either civilian or military transportation. To be in keeping with MAC's mission, wartime resources must be ready to respond to emergencies quickly. They must be exercised in peacetime to maintain their proficiency. Proficiency training is no problem for any airline resources used to fulfill JCS requirements because they will be used in peacetime in commercial areas and perhaps military areas such as channel traffic as well. It can be a problem for the military, however. Too much reliance on commercial augmentation may mean that the military fleet does not get enough utilization during peacetime to assure a surge to full capability when an emergency arises.

After many hearings on military airlift, the question of the level of commercial augmentation remains at the position it was when the airlines began pressing for more military business. MAC, like other government agencies, is charged with promulgating policies that will help develop commercial air transportation; however, it must also consider its war mission and peacetime training requirements. MAC's critics argue that if MAC carries more traffic than required to support the latter, it is an "airline" competing with commercial carriers. MAC argues that if a large commercial augmentation program limits it to a daily aircraft utilization that is too small to keep its personnel trained, then MAC has insufficient wartime capability. So far the difference between the views of the military and the views of the airlines has been resolved politically by appeal to Congress with little accompanying analysis. Throughout the ensuing discussions on military airlift, analytic statements have been confused with statements based on the preferences of those who can exercise some control over how much commercial airlift is used. Further, the discussions have skirted a fundamental issue: What is the government trying to accomplish with commercial augmentation and what constraints limit the program? Thus, in examining issues relevant to choosing the mix of commercial and military air carriers, our first task is to provide a better framework for analysis by setting out the constraints and criteria involved.

III. THE FRAMEWORK

CRITERIA

The hearings on military airlift showed that the people involved in commercial augmentation had very different ideas about how this program was supposed to contribute to the national defense. Congress, by legislation and exhortation, has called for the development of commercial air transportation and has demanded that the military assist in achieving this goal. This criterion does not provide a means for choosing among alternatives because it is too vague. We do not know in what sense air transportation is to be developed. For example, should the military choose the commercial carrier regardless of the cost or the effect on the wartime capability of the military? Similar remarks can be made about the criterion that designates that the mix of carriers be chosen to develop military air transportation. Congress has been interested in encouraging small business and has, from time to time, suggested that the commercial augmentation program be used at least partially for this purpose. The same observations about vagueness apply to this criterion as to the other two. The hearings mention a standard rule: minimize the cost of a given set of requirements. But this is not a clear criterion either since it has been interpreted as applying to the question of the optimum type and amount of airlift to support our national defense in the future. The problem is that we do not know with certainty the level of force capability for which we wish to minimize cost. One reason for the uncertainty is that even the experts do not agree about the nature of the threat against which we will be expected to defend ourselves. This disagreement concerns not only the detailed level of a scenario, but what goes into the makeup of the scenario itself. Also, the planning factors that are used to translate scenarios into numbers of men and equipment are not known with enough accuracy.

None of these suggested criteria imply anything about the goals the Government is trying to attain through use of the commercial augmentation program. In fact, the first three are not really criteria at all, but rather vaguely stated objectives of the program. Cost

minimization, a tool for choosing among alternatives, can be an end in itself. Usually, however, it supports some higher level goal. It appears to us that a good deal of the controversy over commercial augmentation is due to the lack of a clearly stated objective. Those who control the program can materially improve the setting for analysis by defining the pertinent higher level goals and delineating how lower order ones interact. For example, suppose the highest goal is the promotion (in a sense to be defined) of the national defense. When civilian air carriers are given a role in military air transportation, they contribute to the lower goal of generating a reserve of resources, supplementary to the military, to be used in times of emergency. The relationship of this objective to that of guaranteeing a surge capability for MAC must still be delineated.

Since this Memorandum goes beyond setting up a framework for analysis to an evaluation of one of the constraints placed on commercial augmentation, it must have some criterion to use. For the analyst, although not for the decisionmaker, the solution is to use the cost-minimization criterion for several levels of capability. The question probed here, the desired level of commercial augmentation, depends on the total amount of airlift desired as well as on the way the total is to be divided. However, because the arguments over this program have centered on the division of the job between the military and civilian operators, we do not discuss the optimum level of airlift relative to other modes of transportation.

CONSTRAINTS

Several segments of government have some power over the commercial augmentation program, and all of them have imposed constraints on it. Since the DOD is in charge of the program, it has levied the largest number of conditions. First, the Department of Defense has designated certain types of cargo and passengers as eligible only to the military carrier. The JCS Wartime Airlift requirements are broken down into hard-core requirements and other essential requirements. Because of their nature or the nature of the mission, "hard-core or critical

requirements must move in military operated aircraft."* The hard-core requirements have been defined as "airlift requirements which must move in military aircraft, manned and operated by military crews because of the special military considerations, security, or because of limiting physical characteristics such as size or dangerous property. Included in this category are special military deployments involving nuclear retaliatory forces, the SAC post-strike recovery mission, tactical deployments, movements of missiles and special munitions."**

The question of a division of military traffic between military and civilian carriers applies only to MAC's Airlift Service Industrial Fund (ASIF) activities. These include channel airlift, troop carrier activities, aeromedical evacuation, test exercises and special assignment airlift missions (SAAMs), financed through an industrial fund by direct payments to MAC by each of the user services. MAC also performs technical services -- the Aerospace Audio-Visual Service, the Aerospace Rescue and Recovery Service, and the Air Weather Service. As Table 5 indicates, ASIF services account for about half of MAC's aircraft and between a quarter and a half of its personnel.

Table 5

ASIF OPERATIONS AS A PERCENTAGE OF TOTAL MAC ACTIVITIES

Category	1959	1963	1964	1967
Aircraft	48	57	56	51
Personnel	24	31	33	47

SOURCE: U.S. Air Force, Military Airlift Command, Airlift Service Management Report, Scott Air Force Base, Illinois, 1958-1967.

Airline operations are conducted mainly on channel airlift routes and on runs for the Air Force and Navy between their continental bases.

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*Ibid.

**Stanley Brewer and James Rosenzweig, Military Airlift and Its Relationship to the Commercial Air Cargo Industry, Graduate School of Business Administration, University of Washington, Seattle, Washington, 1967, p. ix.

Very little, if any, commercial augmentation is applied to SAAMs, and none to the other ASIF activities.

Even though the "hard-core constraint" is based on the airlift job to be performed during wartime, it affects the peacetime division of military air transportation. Part of the wartime capability desired of MAC is the capacity to surge from peacetime to wartime operations. To guarantee this, the MAC fleet must be exercised during peacetime. One way to assure that this goal is not overridden is to restrict the peacetime operations allowed to the airlines. This is the effect of the second constraint placed on the airlines. DOD directives limit the areas of operation of the Military Airlift Command and the airlines in their military charter work.* Although these directives do not state the limitation directly, they have been interpreted to mean that MAC will not seek commercial augmentation for channel traffic unless its own capability (at some given rate of utilization of the MAC fleet)** is insufficient to satisfy the demand of the various services at the tariffs that MAC posts. In the continental United States, the airlines have first choice with respect to military traffic except for that reserved to the military by virtue of the nature of the cargo or the destination of the mission.

A DOD Directive issued 27 September 1968 apparently establishes a new DOD policy with respect to commercial augmentation. It places more emphasis on the "efficient peacetime utilization" of the military fleet procured to meet JCS approved emergency and wartime requirements and less on the "promotion of civilian air transportation," than the directive previously in effect, but it is too early to tell how the new directive will be construed.

In addition, the DOD placed restrictions on the type of participating contractor. Since Fiscal 1962, an airline must be an air carrier as defined by the Federal Aviation Act of 1958 to be eligible for a

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*See Department of Defense Instruction 4500.23, 1 October 1956, Section III.B.1, and Department of Defense Directive 4500.9, 6 January 1956, and its replacement dated 27 September 1968, Section IV.B.

**The Military Airlift Command operated under a five-hour-per-day flying hour ceiling during the early 1960s.

commercial augmentation contract. This excludes the Part 45 carriers and limits contractors to airlines that are regulated by the Civil Aeronautics Board. A potential contractor must also designate some of its aircraft as part of the Civil Reserve Air Fleet (CRAF). This fleet is comprised of civilian aircraft suitable to augment MAC air transport forces in an emergency. The DOD looks upon this condition as a means of encouraging the modernization of CRAF and increasing its capacity.

Congress has exercised not only indirect control over commercial augmentation through Air Force appropriations, it has also placed a more direct constraint on the program. For several years Congress has earmarked $80 million -- $100 million in Fiscal 1967 -- of the DOD travel funds for use in procuring commercial airlift. Any unused portion of the earmarked funds is returned to the U.S. Treasury.

When the DOD limited contractors to air carriers as defined in the Federal Aviation Act, the Civil Aeronautics Board decided to set minimum prices for military charters. The DOD action paved the way for the Board to make this move; it had hesitated to do this in the past because some contractors were not subject to its regulation. Military contract prices have been the minimum allowed.

All of these constraints limit the alternatives for providing air transportation services to the military. If they reflect physical limitations on the number of alternatives that are attainable, then they do not prevent the choice of a least-cost feasible alternative. Such would be the case if the airlines were incapable of carrying hard-core requirements because of the type of airplanes they own or plan to buy. However, these constraints may merely reflect the preferences of those who have some control over the commercial augmentation program. In this case, they can prevent a least-cost choice. While there is no reason to place cost minimization as the only criterion, and therefore to reject all decisions that rest on other bases, there must be some way to choose among the potentially large number of the latter. One way is to compare the costs a preferential constraint places on the airlift operation with the constraint's value to the decisionmakers. If the latter is higher than the former, those who control commercial augmentation may wish to override the least-cost criterion.

There is reason to believe that the condition that limits hard-core requirements to the military is based on DOD preferences rather than on the physical properties of airlift supplied by the commercial airlines. That is, the constraint does not reflect either physical limitation or the results of some optimizing procedure like minimizing cost. The next section presents the evidence for this hypothesis. We then discuss whether this constraint prevents consideration of cheaper ways of providing airlift.

IV. THE NATURE OF THE HARD-CORE CONSTRAINT

To find out whether or not the hard-core constraint is based on physical limitations, we want to look at the substitution possibilities between commercial and military airlift. This depends on what kind of airlift the military customers demand and how the products of the suppliers differ.*

MILITARY DEMAND FOR AIRLIFT

The demand for military passenger airlift is fairly homogeneous with respect to type of airplane and type of operator because passengers can be accommodated on any type of airplane, albeit in different quantities. Cargo airlift demand is different. It entails a type of airplane and cargo-handling equipment as well as airlift. The services ship some types of cargo that are too large for many modern airplanes. Further, they sometimes want special handling for their cargo, such as refrigeration or the kind of handling required for dangerous articles.

Cargo That Requires Special Handling

Information on the kind of commodities airlifted by the Armed Forces is difficult to obtain. Two types of cargo movements yield data on the special handling characteristics of military commodities: channel traffic and special assignment airlift missions. The best

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*We take this indirect approach rather than looking first at the cross-elasticity of demand because commercial augmentation volume and prices do not constitute data for measuring this parameter. Under the pricing system used for channel traffic, the Air Force charges its customers the same price whether the shipment goes on military or commercial aircraft. For special assignment airlift missions the rates do depend on the type of aircraft used, but this is because rates cover the chartering of the whole aircraft and thus total capacity. The rates would be the same if the aircraft were the same. The cross-elasticity of demand between products A and B is defined to be

$$= \frac{\text{relative change in the quantity of A}}{\text{relative change in the price of B}} .$$

It indicates the degree of substitution between two products.

primary source for channel traffic is the Transportation Control and Movement Document (TCMD card) that is required to accompany such shipments by MILSTAMP regulations.* Unless the cards are held for a special purpose, recordkeeping practices do not permit a time series of these data. The aerial ports that have punch card accounting machines keep the cards on shipments that originate or terminate there in an active file for one year and in a retired file for three years. They are then destroyed.

The RAND Corporation collected TCMD information from eight Continental United States Aerial Ports of Embarkation (APOE) on magnetic tapes for calendar year 1965. The Douglas Aircraft Company's materials handling study (hereafter referred to as the Douglas Study) compiled the data into commodity and cargo handling classes shown in Table 6. Because of reporting errors, the data are not complete. In spite of this, the Douglas Study reports that these records yield tonnage figures for the eight APOEs that are close to export airlift tonnage reported by APOE on MAC J-7 reports.** At present, these are the only published, categorized data on channel airlift.***

Table 6 shows that for all of the APOEs except McChord and McGuire, most of the cargo shipped demanded no special handling. The special handling desired at these two bases was refrigeration, certainly something commercial airlines are familiar with.

Handling characteristics of dangerous material do not prevent the airlines from carrying this type of article either. According to FAA regulations, these are articles defined in 49 CFR, Parts 172 through 178, and include explosives, flammable liquids and solids, oxidizing

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*The acronym stands for Military Standard Transportation and Movement Procedures. This DOD-wide program integrates "supply and transportation actions to assure timely responsiveness of the various supply distribution systems." DOD, Supply Management Reference Book, DA Pamphlet No. 700-1, U.S. Government Printing Office, Washington, D.C., Jan. 1965, p. 104.

**Douglas Study, pp. 10-11.

***Another group of data on channel airlift covering 1967 and the first five months of 1968 has been compiled by the Studies and Analysis Group of the Department of the Air Force. It is collating shipments to Southeast Asia by type of commodity and special handling category. Even

Table 6

CARGO HANDLING CHARACTERISTICS OF CHANNEL TRAFFIC, 1965
(Percentage of Pieces in Each Category)

APOE	No Special Handling	Dangerous Material	Refrigerated Food Stuffs	Security Precautions
Travis	89.6	6.7	(a)	(a)
Dover	84.5	4.8	6.3	(a)
McGuire	59.9	1.8	29.2	1.3
Kelly	92.3	6.7	(a)	(a)
McChord	37.7	2.5	59.2	(a)
Norfolk	89.5	6.2	(a)	3.2
Charleston	88.6	8.9	(a)	(a)
Norton	94.1	1.8	--	(a)

SOURCE: S. Moglewer, et al., Post-1971 Materials Handling Study Final Report, Vol. III, Part I, "Systems Analysis," U.S. Air Force, Aeronautical Systems Division, Wright-Patterson Air Force Base, ASD-TR-67-5, May 1967, p. 19.

[a]Less than 1 percent.

materials, corrosive liquids, compressed gases, and poisonous articles. Cargo classified as dangerous is subject to a great many regulations set forth by the Air Force, the Federal Aviation Administration, and the Department of Transportation covering labelling, packaging, storing and handling, etc.* The FAA and the CAB have exempted airline charters for the military from those parts of the Federal Aviation Act of 1958 that might restrict carriage of dangerous goods, and, as a matter of fact, the airlines have carried all kinds of dangerous articles for the DOD, including Class A explosives. The latter are excluded from commercial carriage by Department of Transportation regulations.

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though they are limited by area, these data will provide a valuable addition to the small stock of information on commodity characteristics of MAC shipments when they are released.

*See U.S. Departments of the Air Force, Army, Navy and the Defense Supply Agency, Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft, U.S. Government Printing Office, Washington, D.C., Air Force Manual 71-4, 7 August 1968; Federal Aviation Administration, Federal Aviation Regulations, Part 103: "Transportation of Dangerous Articles and Magnetized Materials," Washington, D.C., 10 January 1968; and Code of Federal Regulations, Title 49: "Transportation," Parts 171-178, U.S. Government Printing Office, Washington, D.C., 1968.

Although special assignment airlift missions do not represent the majority of MAC shipments, they yield information about the Armed Forces' demand for airlift.* These missions are similar to the charters that the commercial airlines perform in that they provide approximately door-to-door, on-call service. Traffic moves on this type of airlift rather than on channel routes because of the time requirement for the shipment, an off-line destination, or the size and nature of the equipment to be moved.

SAAMs are exempt from MILSTAMP regulations. This means that TCMD cards have not been kept for such missions. Therefore, there are no data on the commodity classification of goods shipped on SAAMs until 1967 when MAC initiated a special data gathering effort. The Command is continuing to collect the data while it sets up an automated procedure for handling them. The data source is requests for SAAMs sent to MAC by various services; i.e., the data do not represent actual movements. The Military Airlift Command has provided RAND with the SAAM records for calendar 1967, excluding special weapons.

Table 7 data are aggregated by the month the request was received and by cargo-handling category. The classified supplement to this Memorandum contains a more detailed breakdown of SAAMs. In contrast to the channel traffic data, the SAAM tonnage for each month except November was approximately evenly divided between "dangerous articles" and "no special handling."

None of the data discussed so far mention outsize dimensions as a characteristic of the cargo shipped. Whether or not it is possible to ship outsize cargo by air depends on the type of airplane and the cargo-handling equipment available. In fact, the term outsize is defined in these terms. Cargo is certainly outsize if it will not go through the airplane door, but it can also be considered outsize because of problems with handling equipment. When there are no facilities for off-loading vehicles at the destination, those that are accommodated on one airplane may not be shipped on a second of no lesser capacity if the first provides for entry and exit under the vehicle's own power

*For example, SAAMs made up about 32 percent of the total MAC ton-miles in fiscal 1966 and 24 percent in fiscal 1967.

Table 7

MAC SPECIAL ASSIGNMENT AIRLIFT MISSIONS, 1967
(Percentage of Pounds of Cargo in Each Handling Category)

Month	Dangerous Materials	Animals	No Special Handling
January	31.8	0.2	68.0
February	47.2	0	52.8
March	45.6	0	54.4
April	51.2	0	48.8
May	54.7	0	45.3
June	54.6	0.1	45.3
July	55.6	0.1	44.3
August	41.6	0	58.4
September	49.4	0	50.6
October	52.4	0	47.6
November	85.9	0	14.1
December	47.1	0.2	52.7

NOTE: Because of errors, only 83.7 percent of the population, measured by tonnage, are usable. On the basis of individual record items, 78.1 percent are usable.

SOURCE: Requests for special assignment airlift missions received by the Military Airlift Command in 1967.

and the second does not. The Air Staff Studies and Analysis Group defines outsize cargo to be any that will not fit on the 88 by 108-inch Air Force 463L pallet.*

It appears that the Douglas Company materials handling study mentioned above contains the only published data on outsize shipments.** It discusses data from two recent surveys that Douglas conducted at Travis Air Force Base. The 1965 survey covered a three-week period

*The commercial pallet is 88 by 125 inches.

**Douglas Study, Vol. IV, Part 2, pp. 7-11. The MILSTAMP system yields data on outsize cargo, although none are currently available to researchers. When any dimension of the shipment is greater than six feet, MILSTAMP instructions call for a "trailer" card to accompany the TCMD card that lists total dimensions. The 1965 TCMD data contained trailer cards but they were of such poor quality that they were not kept. The Studies and Analysis Group report will contain information on the number of Southeast Asian outsize cargo shipments as defined above. The SAAM data have no information on dimensions.

and measured all oversize export cargo. The sample consisted of 1658 pieces. Only 3 percent of the pieces shipped from Travis during this time were outsize to the 88 by 108-inch pallet, but these same pieces constituted 30 percent of the weight and 36 percent of the volume of total export shipments. Length was the factor that made most of the cargo outsize to the 463L pallet. Douglas suggests that a pallet train of 3 pallets would take care of 93 percent of the oversize cargo.

The Douglas Company followed this examination with a ten-day survey in September and October of 1966. The study group measured all outsize cargo arriving at Travis during the period plus the oversize cargo backlog extant at the beginning of the survey -- a total of 1864 pieces. Oversize cargo was 6.3 percent of the total pieces, 20 percent of the weight, and 27 percent of the volume of all cargo shipped during this period. The data indicate that a cargo-handling system that accommodates pieces up to (a) 24 feet long would accept 95 percent of the pieces; (b) 9 feet wide would handle 99 percent of the pieces; and (c) 6 feet high would handle 92 percent of the pieces.

Type of Cargo Moved During Wartime

Since MAC's charter implies that its operations and size are dictated by wartime rather than peacetime demands, we should consider the type of cargo MAC's customers will want to ship during wartime. The data presented above cover the demand for airlift during the Vietnam buildup and so provide information on what demand is like in a limited war situation. They do not, however, convey a picture of demand during the rapid deployment phase that figures into so many of the contingency plans being formulated today. For this situation the "data" consist of estimates of cargo demand tailored to fit a particular scenario. The type of cargo contemplated for airlift depends on assumptions about the size of the confrontation, its location, how fast a "rapid" deployment is wanted, and the cost of airlift, sealift and prepositioning, among other things. Several studies have recommended airlift of vehicles either from prepositioning sites or from the United States during the initial deployment; should such recommendations be adopted, they would increase the present demands for outsize cargo airlift. How much larger

depends on the relative proportions of prepositioning, sealift and airlift. It also depends on questions that are beyond the scope of this study: What scenario do we adopt -- a nuclear war, a Vietnam type war, a rapid deployment, and so on; do we prepare for the scenario with the highest probability given our present point in time, or the scenario that describes the case that puts the greatest demand on our resources; do we try to be prepared for all X number of possibilities? The most we can say without adopting the recommendations of a particular war plan (and that seems unnecessary for purposes of this study), is that some increase in the demand for outsize cargo airlift is to be expected during wartime.

SUPPLY BY AIRLINES

From the sketchy data available, we have found that cargo shippers demand particular kinds of handling. For channel airlift, given the military demands for airlift of the past few years, this special processing has taken the form of refrigeration and outsize cargo handling. For special assignment airlift missions, a good deal more of the cargo was considered dangerous and required special packaging and labeling.

Differences in Supply Due to Type of Aircraft

The airlines have been shipping fruits, flowers and other perishables under refrigeration for quite some time. They have also had experience in transporting all types of dangerous articles. Security precautions do not present obstacles to carrying classified shipments on commercial carriers either. It is well known that many civilian companies have been authorized to handle classified material up to top secret. Their ability to carry outsize cargo is shown in Table 8, which presents two capacity characteristics for the cargo-carrying airplanes purchased by the commercial lines and the Air Force. With the coming of the jumbo jets in 1969, there will be a sizeable increase in the cargo airlift capacity of both the airlines and the Air Force. The 747F will furnish almost three times as much useable cargo volume and the C-5A almost five times as much as the airplanes the carriers operate at present.

Table 8

TYPE OF AIRPLANE OFFERED FOR OUTSIZE CARGO AIRLIFT: AIR FORCE AND COMMERCIAL AIRLINES

Airplane	Largest Cargo Access Dimensions: Height	Largest Cargo Access Dimensions: Width	Airplane Volume Usable for Cargo (cu ft)	Special Features
Commercial				
707-320C	7'7"	11'2"	8,074	--
DC-8F	7'1"	11'8"	8,810	--
CL-44J	6'1"	7'9" (tail)	8,625	swing tail[a]
747F	8'4"[b]	11'4"[b]	23,890	nose loading
Air Force				
C-141A	9'1"	10'3" (tail)	8,730[c]	tail loading with ramp
C-5A	13'6"[d]	19'0"[d]	38,680[e]	nose and tail loading with ramps

SOURCES: Jane's All the World's Aircraft 1966-67 and 1967-68, J.W.R. Taylor (ed.), Sampson Low, Marston & Company, Limited, 1966 and 1967; Lockheed-Georgia Company, C-5A Operational Planning, MER 400, Marietta, Georgia, July 1967, p. 6; The Boeing Company, Commercial Airplane Division, Everett Branch, Boeing 747 Cargo and Baggage Systems, D6-13912, Renton, Washington, October 1967.

[a] The swing tail permits loading into the full cross-section of the main cabin, tail area, and rear under floor hold. The cabin dimensions are the following: width at floor, 11'0", and the maximum height is 6'9".

[b] Nose cargo door. The right side of the airplane has two 104" by 66" rectangular cargo doors.

[c] Including ramp area.

[d] These are the dimensions for the forward loading opening. Dimensions for the aft loading opening are as follows: height, 9'6" and width, 19'.

[e] Including troop compartment.

The freighter version of the Boeing 747F has both nose and side loading, but cannot handle heavy vehicles because the floor is not stressed for such dense loads. Further, it lacks the integral ramps that allow vehicles to roll on and off of the plane, and thus requires large loading platforms. Lockheed designed the C-5A to handle heavy

vehicles; it has a floor stressed for heavy loads with both nose and tail-ramp loading. It has been designed to land on unimproved strips. Commercial airliners are not so designed. The C-141 and C-5A also have an advantage over the commercial airplanes in that they require shorter takeoff and landing distances.

According to the Douglas outsize cargo studies mentioned above, however, all of the existing cargo airplanes except the CL-44J have cargo doors wide enough to accommodate 99 percent of the pieces outsize because of width and 92 percent of pieces outsize because of height.* The 707-320C and DC-8F might have some trouble accommodating pieces outsize because of length since they do not have end loading.

<u>Differences in Supply Stemming from Ownership of Airlift Services</u>

Because the military demand for airlift includes transportation during emergencies, a question arises about differences in availability and speed of response due to differences in the ownership of airlift resources. The Air Force has been concerned that they would be unable to obtain the services of the commercial airlines to the extent they wished if an emergency short of full-scale war arose during the season of peak commercial demand. Of course, there is a price that the military could offer the airlines that would bid resources away from commercial uses. The question, then, is not whether the airlines will perform military services, but at what cost. A more relevant consideration with respect to ownership is how fast (relative to military resources) commercial planes and crews can respond to a sudden, large increase in demand.

The Civil Reserve Air Fleet (CRAF) was set up to deal with both of these problems. Each contractor allocates some of its equipment by tail number to the CRAF. In their contracts with the Department of Defense, the airlines promise to supply these predesignated airplanes within 24 hours. The activation procedure was divided into

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*The CL-44 cargo door is too narrow to be included in this statement.

three stages in 1963 to assure emergency airlift under conditions short of general war and at specified prices: the Secretary of Defense or his designee mobilizes Stage I under conditions of an "airlift emergency;" a Stage II emergency named by the President calls into use a larger number of airplanes than Stage I; Stage III activates all commercial airlift forces promised to the Fleet. Data generated by a mobilization of this Fleet would allow a check of hypotheses about the responsiveness of the commercial fleet. However, the CRAF has never been activated even though it has existed since 1952.

There have been a number of tests of the Fleet, but they all consist of moving resources around on paper. None examine the responsiveness of CRAF; each assumes that the planes will be available according to the provisions of the commercial augmentation contract. To date there have been five CRAF exercises: "Snowflake," August 1959; "Mixed Double," 15 February 1966; "Cold Scarf I," 28 December 1966, "Cold Wire," 3 July 1967; and "Cold Scarf II," 15 July 1968. MAC recently decided to conduct annual CRAF exercises along the lines of these tests.

The exercises were designed to locate problems with other aspects of the activation of CRAF than the speed of response. The primary objective of these tests has been to check the communications of the CRAF Airlift Scheduling Center with the carriers. Some of the other facets MAC examined include activation of a Senior Lodger Station,* review of the purpose and requirements of the CRAF program, and study of CRAF publications.

The fact that CRAF has not been called up shows that the Air Force has been able to secure commercial augmentation during emergencies at prices, quantities and response times that they deemed acceptable; the alternative of activating CRAF was always available. As a matter of fact, several airlines recently found it profitable to cut their commercial schedules during the peak summer season to provide services to the

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*A Senior Lodger is a predesignated CRAF carrier that has been assigned by MAC as the coordinating agency for all activities concerning CRAF operations into a designated dispersal/regroup base when CRAF is activated and where operation from a dispersal posture is required.

military. In addition, Fig. 1 shows that the airlines have handled two very sizeable increases in demand for commercial augmentation without the aid of CRAF.

Regardless of the speed of response and availability, planning and information would certainly be easier for military commanders when resources under military jurisdiction are owned and therefore completely controlled by the military instead of by civilians.

Problems of Civilians Operating in Combat Zones

As any buyer does, the military considers the quality of its purchase as well as the price. No one claims that a Volkswagen is always better for a civilian buyer than a Buick simply because it is cheaper. There is no reason why the military should not have the same range of choice. Besides the type of aircraft and the speed of response, there is a third quality aspect of airlift that the military takes into account: the Congressional hearings on military airlift contain expressions of doubt about the wisdom and feasibility of allowing civilians into combat zones. Some of the potential problems include (a) insurance for personnel and property; (b) status of forces agreements and prisoner of war agreements that cover the relationship of military personnel and the laws of foreign countries, as well as treatment of personnel while detained by enemies of the United States; and (c) medical attention.

In the commercial augmentation contract, the Air Force explicitly recognizes that the airlines might have difficulty in buying war risk insurance at prices comparable to normal coverage, so it has provided for Government indemnification of the contractor against loss of aircraft or other property and death, disability, disease, injury, or impairment of rights of persons.* The Federal Aviation Act of 1958 authorizes the Secretary of Commerce to provide insurance against loss of life, injury or detention arising out of war risks when insurance "adequate for the needs of the air commerce of the United States" cannot be obtained on "reasonable terms."**

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*Indemnification depends on the availability of appropriations.

**49 USC 1532.

When a civilian is acting under orders of the Armed Forces, as airline personnel would be doing under activation of CRAF for example, he can be issued a Geneva convention card that states:

> The bearer of this card is a civilian noncombatant serving with the Armed Forces of the United States, whose signature, photograph, and fingerprints appear hereon. If the bearer of the card shall fall into the hands of the enemies of the United States he shall at once show this card to the detaining authorities to assist in his identification. If the bearer is detained he is entitled to be given the same treatment and afforded the same privileges as an individual in the grade, rate or rank of the military service of the United States indicated below, with any and all rights to which such personnel are entitled under all applicable treaties, agreements and the established practice of nations.*

Although this card may not solve the status problem of civilians operating in combat zones because the enemy may choose not to recognize it, it shows that a mechanism has been set up to protect civilians in these circumstances. Since it has been used and is still retained, it appears that no serious problems connected with its use have arisen.

The Air Force has also recognized the problem of medical aid for nonmilitary personnel; civilians acting under military orders may receive medical attention at military facilities. Although the Armed Services have set up machinery to deal with civilians in combat zones, and there have been wartime situations before Vietnam in which they have participated, it is rational that military personnel would prefer to have all of the people they work with under their control.**

SUMMARY

This section has considered the degree of substitution between military and civilian airlift in order to determine whether the hard-core constraint is based on physical limitations of airline services relative to military demand for airlift. First, the type of airlift demanded by military customers was examined. Since passenger transportation does not depend on the type of airplane used, cargo demand

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*Department of the Air Force, Air Force Regulation No. 30-20, Issue and Control of Identification Cards, 14 June 1965, p. 16.

**See the comments about the operations of Air America in Cecil Brownlow, "Sustained Viet Buildup Urged to 1972," Aviation Week and Space Technology, Vol. 86, No. 4, 23 January 1967, p. 27.

received detailed attention. The data available indicate that there are two kinds of demand for cargo airlift; some cargo can be shipped with no particular attention to processing, but other cargo requires special handling. The special procedures involve refrigeration and activities pertinent to dangerous materials, classified shipments or outsize cargo.

Second, the supply by the airlines was reviewed. It is physically possible for commercial aircraft to meet all military cargo demands except for outsize cargo made up of vehicles, and perhaps cargo outsize because of length. The planes the Air Force purchased have a couple of advantages over the planes that will be in the airlines' inventory in the near future: (1) they have the ability to carry and easily load and unload vehicles; (2) they can accommodate cargo that is outsize because of length since they have end loading rather than side loading.* On the other side of the ledger, most cargo outsize because of width and height can be accommodated by existing and planned commercial cargo planes, where outsize dimensions are measured by the Douglas Study.

Besides differences in type of aircraft, there may be distinctions in the supply of airlift due to ownership and the fact that operations are conducted in combat zones. Although the Air Force has been able to secure airline services at rapid enough response times to eliminate the alternative of activating CRAF, there are no data on this variable under emergencies that demand a surge. Until CRAF is tested in the field, the response time of civilian resources remains an open question. Any differences in supply because civilians do not ordinarily enter combat areas lie more in the realm of preferences rather than physical limitations because the Armed Forces have set up the mechanics for such operations.**

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*Note that Lockheed has no restrictions against selling these planes to civilians. If the airlines saw a market for them -- and this would probably be a military market -- they would buy them.

**There is one further consideration pertinent to a discussion of the degree of substitution between the two types of air carrier: if commercial resources are committed to a wartime job, the civilian sector of the economy will yield resources to military operations, such as the maintenance of routine channel missions, during the emergency.

In the light of the admittedly sketchy data we have looked at, there are large possibilities for substitution between the military and civilian air carriers. The hard-core constraint, then, appears to be imposed on the basis of preferences rather than physical limitations. The problem with a procedure like this is that one constraint leads to another. If the Air Force is equipped to furnish hard-core airlift during wartime, it is also being provided with a peacetime capability. This capability is quite cheap relative to alternatives because it is available at marginal cost; investment costs are charged to the wartime job. Thus the constraint on what the airlines can carry during war carries over into a restriction on their activities during peacetime.

V. COST OF THE HARD-CORE CONSTRAINT

Military use of civilian air carriers is limited by the DOD restriction placed on the type of goods "eligible" for civilian airlift. Section IV shows that this policy is, for the most part, not required by the physical nature of the goods to be airlifted, the characteristics of the equipment the airlines own or the difference in the legal status of civilian and military personnel. An alternative explanation for the policy is a military preference for control over all resources within its sphere of operation. The cost associated with such a preference therefore becomes highly relevant. By preventing the consideration of a feasible alternative to military airlift of military traffic, such a restriction may prevent the choice of a least-cost way of providing airlift. This section presents the available methods for finding out if such has been the case with respect to the hard-core constraint.

ASSUMPTIONS AND METHODOLOGY

To determine whether the hard-core constraint places a cost on the military transportation system, we consider the hypothetical policy of purchasing an increment in airlift services from civilians relative to the costs of the policy of furnishing the airlift in-house. If one compares the commercial and MAC costs for a particular job, with no limitations on the type of operations of either, one can get an idea of the cost of the constraint. In essence, look at the cost differences among alternatives, ignoring the constraint. Let us examine the cost of procuring and operating in all-cargo configuration a block of C-5A airplanes in addition to the 58 the Air Force already purchased. As a hypothetical example, let us inquire about the cost of purchasing and operating the 57 C-5As that comprise the production run B option of the C-5A contract with Lockheed.* An examination of the models presented below will show that any other number would do equally well. The two imaginary fleets to be compared are shown in Table 9.

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*U.S. Air Force, Director of Management Analysis, USAF Management Systems: Designated Systems, AMA 68-0684, 30 June 1968, p. 21. Military

Table 9

COMPOSITION OF FLEETS COMPARED[a]

Fleet	C-5A	All Other Aircraft	Ownership
A	115	X	MAC
B	58	X	MAC
	57	-	Airlines

[a]Both fleets are assumed to have the same physical capability.

The same airplane is used in these two alternatives in order to emphasize cost differences that stem from differences in areas other than equipment. There is a good deal of substitution possible between the carriers with the equipment they have in their inventory and on order, and also there is no reason why both types of carriers cannot obtain the same equipment. We used two cost models for our comparisons. For military operation of the C-5A, we use a model developed by the Cost Analysis Department of RAND, and for airline operation, we use a model developed by the Research Analysis Corporation.

MILITARY AND AIRLINE OPERATION OF THE C-5A

The Airline Model

When the Research Analysis Corporation (RAC) sought a cost model to estimate the costs of operating the supersonic air transport and other advanced aircraft, they tested against actual costs the five models that reflected the best research completed at that time.* Their

demand for transportation, as we have seen, includes not only ton-miles of transportation but also the type of airplane itself, since it is the wartime demand for airlift that dominates. The Air Force has contracted to purchase the C-5A aircraft because it has characteristics, such as the ability to carry heavy vehicles, that are deemed important to meet wartime airlift demand. For these reasons, we have chosen to examine the costs of adding some number of airplanes rather than some number of ton-miles to MAC's airlift capacity. If the latter assumption had been adopted, the cost differences between military and airline operations discussed below would be changed in direction and size.

*R. A. Booth, et al., Cost Analysis of Supersonic Transport in Airline Operations, 2 vols., Research Analysis Corporation, McLean, Virginia 31 December 1966.

model combines some aspects of several of the models tested. It estimates costs for a "representative firm," on a route characterized only by distance.

The RAC model consists of equations that are dichotomized into direct operating costs, which measure costs that cover the operation of the airplane, and indirect operating costs, which measure costs that deal with the handling of passengers and cargo. For this study, the model was run for trips of 1500, 2000, 3500 and 4500 statute miles in an all-cargo operation. It was also run for three different yearly aircraft utilization figures thought likely for the Boeing 747, an airplane comparable in size to the C-5A. Only operating costs are considered; investment in terminal facilities, runway strengthening, and other costs incurred to put the first C-5A in operation are assumed to have already taken place, since we are considering an addition to an existing stock of airplanes. Operating costs include allowance for depreciation.

A detailed account of the assumptions that lie behind the equations may be found in the RAC document describing the model.* Here we present a general idea of the variables used in the estimates. The Appendix contains a complete list of the equations and the values of the exogenous variables used to compute costs. Some costs, such as fuel, crew and aircraft control are fixed estimates of future costs; that is, they are not derived as functions of exogenous variables. Others are functions of particular variables.

Maintenance costs, for instance, are based on the weight of the airplane, the weight of the engines, and engine thrust. This means that the model yields similar maintenance costs for airplanes that weigh similar amounts even if one of them has more complicated components. An example that quickly comes to mind is the Boeing 747 versus the C-5A. The latter has a complicated landing gear that gives the airplane rough field landing capability. It could make maintenance costs higher, at least on this component.

The parameters of the maintenance equations are based on a method of accounting for maintenance costs called the Air Transport Association Spec 100. It breaks costs down into much finer detail than reports

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*Ibid.

that the airlines submit to the CAB as part of their reporting requirement. This extra detail is supposed to improve maintenance estimates. The costs used to determine the parameters are averages of actual costs incurred by American, United, and Continental Airlines during 1964 and 1965 and reported on ATA Spec 100. These costs are increased by applying the ratio of the weight of the advanced airplane to the weight of the Boeing 707, the airplane for which Spec 100 costs were reported.

Maintenance burden (those costs attributed to the supervisory organization that directs the maintenance facility) is computed as a percentage of total maintenance cost. The depreciation cost contains an assumed spares ratio of 30 percent for engines and 10 percent for the airframe.*

The parameters contained in the indirect operating cost equations were taken from extrapolations of a three-airline average of the available time series of data. In some cases this means projections of a trend; in others it means using the same value as the last year of the series--in most cases 1965. The Appendix contains the costs estimated by the RAC model for airline operation of the C-5A broken down by equation, utilization and trip distance.

The Military Model

The military model, developed by RAND's Cost Analysis Department, is organized differently from the airline model. The cost categories are fewer. All of the equations contain components that are fixed relative to the exogenous variables. For example, the model computes expenses incurred for petroleum products by applying a fixed factor of $342 per flying hour to the total number of flying hours for the fleet. The factor comes from estimates prepared by Hq USAF, Directorate of the Budget, Cost Division. "Modification and Recurring Aerospace Ground Equipment," "Depot Maintenance," and "Annual Replacement Spares" are computed in the same manner. Some costs other than personnel expenses are based on the number of people estimated to run the operation. "Vehicles and Other Base Maintenance Equipment" and "Other Support" costs

*Depreciation covers the price of the airplane and the spare parts purchased with it.

depend on a fixed dollar cost per military employee. The Appendix contains a list of the equations making up this model, and the output of the JOSS program used to make the calculations.*

To assess the effect that flying hours have on military costs, the model was run for four values of this variable chosen to yield values that were low, standard and high relative to the number of future flying hours programmed by the Air Force for the C-5A. The RAND Cost Analysis Department felt that the different flying hours called for varying crew ratios rather than the one planned for C-5A operations because using one ratio for all of the cases of flying hours resulted in underutilization or over-utilization of crews relative to the planned number of flying hours per crew. As with the airline model, none of these costs include investment in facilities. We note, however, that they exclude the airplane cost because there is no allowance for depreciation. Many of the fixed factors have been estimated from data on Air Force-wide activities rather than MAC operations alone. The costs that depend on such factors, then, represent some kind of "average."

An Illustration of C-5A Costs

Tables 10 and 11 present the 15-year costs estimated by the two models for civilian and military operation of a single C-5A. The RAND model, Table 10, computed military costs per flying hour. To obtain numbers comparable to airline costs, which are computed as costs per trip, we multiplied hourly flying costs times yearly flying hours to get yearly costs per airplane. Column 6 multiplies the latter by 15 years. And column 7 adds the investment cost of the airplane including research, development, test and evaluation expenses. This particular interval was taken because it is the length of the depreciation period in the airline model. At the end of 15 years, the airplane would be fully depreciated and thus all of its costs included in both cost estimates.

The airline model, Table 11, computes trip costs based on three different assumptions about yearly utilization. To put these into

*JOSS is the trademark and service mark of The RAND Corporation for its computer program and services using that program.

Table 10

ILLUSTRATIVE OPERATING COSTS OF THE C-5A: MILITARY COSTS PER AIRCRAFT
(Costs in dollars)

(1) Trip Distance[a]	(2) Yearly Trips	(3) Yearly Fly Hrs	(4) Operating Costs ($/Fly Hr)	(5) Yearly Cost	(6) 15-Year Cost	(7) 15-Year Operating Cost Plus Airplane Cost[b]
2000	365	1570	1617	2,538,690	38,080,350	59,512,350
4500	208	1914	1575	3,014,550	45,218,250	66,650,250
1500	730	2409	1536	3,700,224	55,503,360	76,935,360
3500	365	2665	1522	4,056,130	60,841,950	82,273,950

[a]Statute miles.

[b]Total price of the airplane including RDT&E is $21,432,000.

Table 11

ILLUSTRATIVE OPERATING COSTS OF THE C-5A: AIRLINE COSTS PER AIRCRAFT
(Costs in dollars)

(1) Trip Distance[a]	(2) Utilization (hrs/yr)	(3) Cost/Trip	(4) Yearly Fly Hrs in MAC Ops	(5) Block Time (hrs)	(6) Yearly MAC Trips	(7) Yearly Cost in MAC Ops	(8) 15-Year Cost
	3300	18,354				6,699,210	100,488,150
2000	3800	17,994	1570	4.3	365	6,568,175	98,522,625
	3900	17,934				6,545,910	98,188,650
	3300	22,882				4,759,456	71,391,840
4500	3800	22,120	1914	9.2	208	4,600,960	69,014,400
	3900	21,991				4,574,128	68,611,920
	3300	16,507				12,050,110	180,751,650
1500	3800	16,232	2409	3.3	730	11,849,360	177,740,400
	3900	16,186				11,815,780	177,236,700
	3300	21,645				7,900,425	118,506,375
3500	3800	21,034	2665	7.3	365	7,677,410	115,161,150
	3900	20,935				7,641,275	114,619,125

[a]Statute miles.

yearly costs, we obtain the trips per year that the airlines fly for MAC (Col. 6) by dividing the same number of flying hours per year used in the military model (Col. 4) by the block time for each type of trip.*

Observe from Table 11 that utilization makes no sizeable difference in costs. Further, the importance of trip costs is quite startling. The 1500-mile trip has fewer flying hours per year than the 3500-mile trip does, but it yields twice as many trips per year because of the short block time of 3.3 hours. The costs are nearly half again as high for the shorter trip.

The figures presented in Tables 10 and 11 show a striking contrast. The airline costs are much higher than those for the military. Some of the difference may be explained by lower military manpower costs stemming from the draft. However, for reasons to be discussed below, the costs are not comparable and cannot be used to assess the hard-core constraint. It is important to note, nonetheless, that if they could be compared, they would imply a negative cost for the hard-core constraint. To find an objection to keeping the constraint, the saving from producing airlift in-house would have to be weighed against the value of possible objectives of the commercial augmentation program, such as the civilian reserve resources the program supports for use in wartime.

LIMITATIONS ON THE USE OF COSTS TO ASSESS THE HARD-CORE CONSTRAINT

The previous subsection presented estimates of the costs of military and airline operation of the C-5A, but did not compare them. We

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*Block time is the interval it takes to go from the origin loading ramp to the destination loading ramp. We do not discount these costs because the discount factor is the same for the two cost streams we are comparing. Since the costs are distributed uniformly over the period, the present value of the cost stream is

$$A \sum_{n=1}^{15} 1/(1 + i)^n ,$$

where A is the cost per year. If i and the limits of the sum are the same for both cost streams, the discount factor will be the same for both, and the comparison is the same with or without discounting. The rate of discount, i, measures the return of the resources used in these projects in their next best alternative employments. Because the Government project takes resources that would be used alternatively in the private sector, its rate of discount is the same as that for industry.

went through the exercise of computing these costs because it shows where some of the pitfalls of such a project lie, and how further research with cost models can help resolve the commercial augmentation issue.

First, the amount that MAC pays for commercial lift depends on CAB minimum prices. The minima are based on costs plus a 9-percent rate of return on investment after taxes, but such amounts cannot be obtained from the costs derived above. Some of the costs allowed by the CAB are not included in the civilian model we used. For example, the model considers only hull insurance in contrast to the CAB method of computing cost, which also incorporates liability and property damage insurance. The CAB includes income taxes, the model does not. Further, the parameters of the model do not depend on specific routes. The CAB attempts to calculate costs that stem directly from MAC operations. We emphasize this point to preclude improper use of these costs, although at worst, the cost estimates are a lower bound.

More serious problems arise from using two different models for the cost comparison. A clear solution to them appears at once; use one model. There are, however, compelling reasons for using two models. A neutral model that can cover both types of operations has not been developed. Therefore, we use the hypothesis that each operation has a different production function. This means that the equations that make up the cost models of their operations have different functional forms with different independent variables. For example, we expect crew costs to be higher for the airlines since the military does not secure its personnel competitively. Further, the equations for estimating maintenance are likely to depend on different independent variables and have different functional forms. In normal parlance, sets of equations that have such differences are considered separate models.

The biggest difficulty is differences in fit. If one model is biased upward and the other is biased downward, the cost comparison will show a large difference when, in fact, there is none. The set of equations used to calculate MAC costs has not been tested against actual costs. The RAC model was chosen because it gave the best fit for aircraft for which data exist. Neither model has been matched against C-5A data, of course, since the aircraft is still being tested.

Differences in the level of completeness, partly a function of generality, can also cause spurious contrasts. The model used to estimate the costs of MAC airlift is quite a bit more general than the airline model because data on certain detailed activities are not available. For example, it does not distinguish whether the plane is used for cargo or people. The airline model does make this distinction, but the passenger cost equations are not shown in the Appendix because the model was run for an all-cargo operation. Thus all passenger handling costs such as meals and reservations--costs to the military as well as the airlines--are ignored.

It appears that one of the major differences stems from the fact that the models do not measure costs in real terms, but in money terms.* The real cost of buying and operating a block of airplanes is measured by the value of the product the economy gives up by devoting resources to this particular job rather than something else. Money costs sometimes do not correspond to this latter measure. For example, when comparing the costs of military and civilian operation of fifty-seven C-5As, one must consider that military manpower costs are lower than civilian because the military secures manpower under the draft. Thus military pay rates understate the cost to society of using resources in military operations.

Even though these models probably represent the best that the state of the art has to offer, they cannot generate costs that can compare airline and MAC operations. We have noted some likely problems that could make them incomparable. In addition there is evidence from the costs they generate that the models are incommensurate. The models imply vastly different trip costs that are invariant as flying hours change. There are some costs that vary with trips no matter how many hours the trip takes and some that vary with the number of flying hours.** The models imply very different trip costs.

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*I am indebted to D. F. Loveday for this point.

**For the airline model, flying hours per year are generated by multiplying block time by the number of trips per year.

Figure 2 shows airline and military costs per trip plotted against trip distance. A hypothetical relationship between the two variables is obtained by drawing a line through the two distance-cost points that reflect the same number of trips per year. The latter statistic is shown in parentheses. The middle line in Fig. 2 includes a per-trip allocation of the procurement costs. This was necessary because the military operating costs do not include depreciation, but the airline operating costs do. As flying hours decrease, keeping the number of trips per year constant, military trip costs approach about $5.5 million and airline trip costs approach $14 million. This discrepancy raises the possibility that the airline model contains costs other than marginal costs. Indeed, it does have many cost categories that are merely allocations of overhead and therefore do not change as output changes.

Even though the military and airline costs are not comparable, we can quickly check the relevance of the airline costs to current MAC operations by looking at the model's implied ton-mile costs relative to CAB minimum prices now in effect. Table 12 shows that ton-mile costs range from 7 to 10 cents. The latest CAB minimum price for round-trip channel charters using regular turbojet or DC-8F-61 or -63 aircraft is 7.06 cents per ton-mile.* Since several airlines, for example Continental, have purchased aircraft for specific use in MAC operations, there is reason to believe the minima cover total rather than only out-of-pocket costs. This comparison suggests that the estimates of Table 11 are high.

Besides operating costs, any comparison between military and civilian C-5A operations must take account of at least two more costs on the airline side of the ledger. We have chosen to lock the airlines into buying the C-5A, but none of the airlines have ordered that airplane. They have been looking at a civilian version of the aircraft, but it is an entirely different aircraft. This suggests that the Military Airlift Command would have to offer the airlines an inducement

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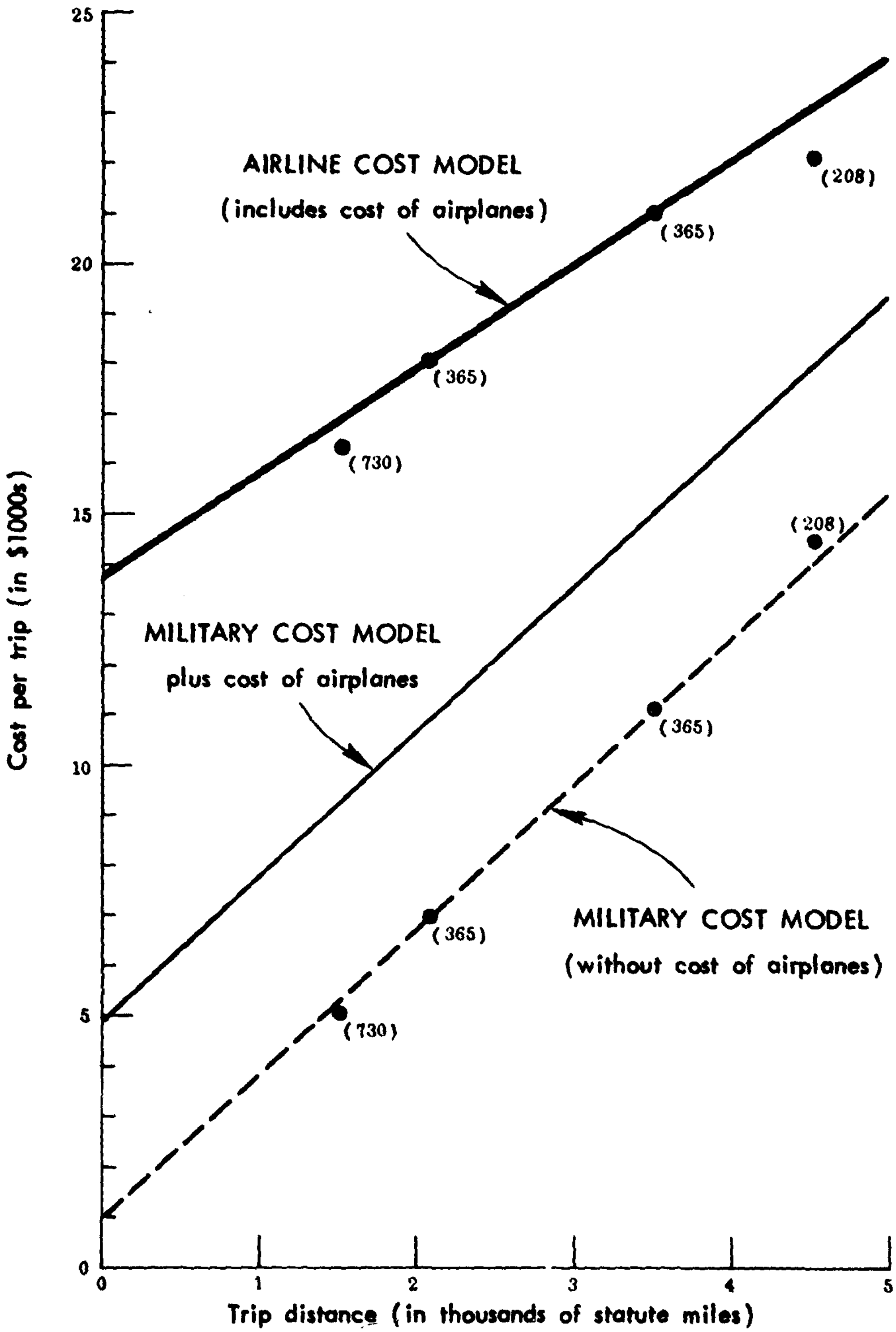
*U.S. Civil-Aeronautics Board, Regulations of the Civil Aeronautics Board, U.S. Government Printing Office, Washington, D.C., 1 November 1963 (looseleaf updated through 1968), ER536, 1 July 1968.



NOTE: Figures in ( ) denote number of trips per year.

Fig. 2 -- Fixed trip costs implied by the airline and military cost models

to buy the C-5A rather than an alternative like the Boeing 747 or the civilian version of the C-5A if it wanted to buy the services of the former plane from the airlines. Further, the airlines conceivably could require a bonus to guarantee their services during contingencies.

Table 12

TON-MILE COSTS IMPLIED BY AIRLINE MODEL[a]

Trip Distance	Tons	Ton-Miles Per Trip	Cost Per Trip ($)	$ Per Ton-Mile
2000	110	220,000	17,995	0.0818
4500	55	247,500	22,120	0.0894
1500	110	165,000	16,232	0.0984
3500	82.5	288,750	21,034	0.0728

[a]Utilization is 3800 hours per year.

To generate some evidence on the first of these potential costs, we have run the RAC model for the Boeing 747. As an interesting by-product of this exercise, we see some more of the built-in assumptions of the model. Table 13 shows that the model computes a higher direct operating cost for the C-5A than the 747 for all three utilization assumptions. Indirect costs are lower for the 747 for 2000-mile and 1500-mile trips but not for the other two trips. The reason is that, at 3500 and 4500 miles, the 747 carries a larger payload than the C-5A. Cargo handling and freight expenses depend on payload and so are higher. Further, the indirect cost category "ground property and equipment" depends on direct maintenance labor costs. Because maintenance costs depend on airframe and engine weight, and the engine thrust, all 747 maintenance costs are higher because it weighs more and has larger engine thrust. The cost differences the model estimates are rather small and probably insignificant. The model does not present a clear choice between these two airplanes because their physical characteristics are so similar.

As far as guaranteed service during contingencies is concerned, the military already has a contract with the airlines covering this situation in the form of the provisions for CRAF contained in every

Table 13

COMPARISON OF AIRLINE OPERATING COSTS: LOCKHEED C-5A AND BOEING 747 FREIGHTER
(Dollars per Trip)

Operating Cost	Statute Miles							
	2000		4500		1500		3500	
	747	C-5A	747	C-5A	747	C-5A	747	C-5A
	Utilization = 3300 hours per year							
Direct	7,380	7,739	15,265	15,763	5,716	6,034	12,344	12,777
Indirect	12,808	13,424	12,736	10,279	12,000	12,580	13,954	12,465
Total	20,189	21,163	28,001	26,043	17,716	18,614	26,298	25,242
	Utilization = 3800 hours per year							
Direct	7,080	7,385	14,628	15,011	5,489	5,763	11,834	12,174
Indirect	12,804	13,419	12,727	10,269	11,997	12,576	13,947	12,457
Total	19,885	20,804	27,355	25,280	17,485	18,339	25,781	24,631
	Utilization = 3900 hours per year							
Direct	7,030	7,324	14,520	14,883	5,449	5,717	11,747	12,076
Indirect	12,804	13,418	12,726	10,268	11,996	12,575	13,946	12,456
Total	19,833	20,743	27,246	25,151	17,446	18,293	25,694	24,532

NOTE: The distinction between direct and indirect costs rests on costs that stem from operating the airplane and those that stem from processing cargo and/or passengers.

Components may not add to total due to rounding.

The total costs shown here are larger than those of Table 11 because the former include advertising expenditures and commissions that are a part of regular airline operations but not of MAC charter flights.

commercial augmentation contract. In addition, the military has been able to secure the services of the airlines during the Vietnam buildup at the CAB minimum prices and at sufficiently fast response times and quantities that it has not felt called upon to activate CRAF. For larger conflicts, the military will probably commandeer the airline fleet.

VI. HOW TO FORMULATE THE DESIRED SIZE OF COMMERCIAL AUGMENTATION

SUMMARY

This Memorandum has discussed some of the issues relevant to deciding on the desired level of commercial augmentation with the hope of clearing up the confusion between technological constraints and preferences that has obscured previous discussions. This program is and has been important to both the airlines and the military. In recent years the airlines have carried most of the passengers on channel routes and a sizeable portion of the cargo as well. Some airlines, such as the all-cargo carriers and supplementals, have depended on military contracts for over 50 percent of their revenue. Other, less dependent airlines, have found such contracts profitable enough to seek their increase.

The discussions of the program have skirted a fundamental issue: What is the Government trying to accomplish with commerical augmentation and what constraints limit the program. The study has focused on cost minimization for a given amount of airlift as the criterion for choosing among alternative ways of providing air transportation to the Services. From among the various constraints on the program, we looked at the one that limits the airlines to "civil eligible requirements." The evidence available suggests that this constraint is based on preferences rather than on actual physical limitation on the type of services the airlines can perform. This makes it important to look at the cost of the present division of effort between MAC and the airlines. Once appraised of its cost, the agencies that make decisions about commercial augmentation will have an idea of how much their subjective valuation of the constraint should be to warrant keeping it. Although models among the best that research has provided are used, they turn out to be incommensurate and cannot provide an assessment of the cost of the civil eligible constraint.

Nothing here says that the level of commercial augmentation will or should be determined solely on costs. We do point out that, since not everyone can impose even a few of his preferences on the program, one way to evaluate conflicting expressions of preference is to rank

them by their consequences with respect to cost. The military has primary responsibility over operations in the combat environment. Therefore, they will ask that commercial enterprises not operate there. They feel that any increase in costs, if indeed there are any, is offset by being able to have close control over what is, after all, a military action.

SUGGESTIONS FOR FUTURE RESEARCH

It would be interesting to test the hypothesis that military and civilian air transport operations have different production functions because if they do, this implies that one should develop two models. Our research has produced some notions of the pitfalls to avoid in designing models that are comparable and do measure differences in military and civilian air transport operations. Several points should be considered to avoid spurious contrasts. First, both models should be tested against the data to determine any biases. Second, both should be on the same level of generality to ensure to some extent that they include all of the relevant costs. Third, the models should reflect only marginal costs. Allocating costs such as administrative expenses to various operations puts elements of cost into the model that do not vary with output. Fourth, models that depend on physical characteristics of the airplanes rather than on other operational aspects to be costed, such as the route, are limited in the differences they can measure.

Research into the construction of a neutral model, one that measures the costs of both operations, may also be fruitful if evidence shows that institutional factors such as the draft are more important in explaining differences between the two kinds of operations than technological factors such as different production functions. This kind of a model would be constructed so that the functional forms of the equations would be the same for both operations but the inputs would differ. The costs for both operations should be measured by the value of the product the resources could produce in their most valuable alternative employment because the choice of producing airlift in-house or with civilian contractors should be based on the cost to society of using the resources.

Although the Air Force has or is in the process of acquiring data on the cargo characteristics of the shipments it makes, no data exist on a time series basis. We believe that the value of such data in further studies of commercial augmentation and other areas, such as planning for air terminals and cargo handling equipment, will greatly outweigh the cost of collecting them.

Some consideration should be given in future studies to the goals of the commercial augmentation program. How do these goals fit in with higher level objectives of the military such as the promotion of national defense? Do they conflict with other goals such as the desire to maintain military resources with the capability to surge? They are certainly essential to any evaluation of programs such as CRAF that are subsidiary to commercial augmentation. Suppose the objective of the program is to produce a certain amount and type of transport capacity, for use in emergencies through the mechanism of CRAF, that would not be available without commercial augmentation. Then this capacity should be explicitly included in JCS planned "requirements," and the commercial augmentation program should include incentives to the airlines to allocate the desired type and number of aircraft to CRAF. When comparative cost data are available, this goal can be evaluated. It may be cheaper to have such reserve capacity owned by the military.

In the absence of evidence about an optimal division of effort between the military and civilian air carriers, there is no basis for changing the present allocation. Statements about the comparative costs of military versus private enterprise sometimes assume that civilians can produce things more cheaply. The costs we generated have not verified this; of course, they do not support the opposite hypothesis either. Before a definitive statement can be made about the level of commercial augmentation, the data and theory called for must be acquired. Without these data and without a theoretical basis for comparing the cost of alternative ways of furnishing military airlift, definitive analysis of the desired level of commercial augmentation must be limited to setting forth a framework and making recommendations for future research.

Appendix

THE COST MODELS AND MODEL INPUTS

Table 1

AIRLINE OPERATING COST MODEL
($ per trip)

Direct Operating Costs[†]

1. Flight-crew expense = $\$245\ T_b$
2. Fuel and oil = $F_b(1.2)/6.7 + .13[(7.50)N_eT_b]/8.1$
3. Maintenance
   - Airframe labor = $W_e[T_b(1.4593/10^4) + 2.898/10^4]$
   - Airframe material = $W_e[T_b(1.1812/10^4) + 2.9613/10^4]$
   - Engine labor = $W_q^{1/2}T^{1/2}N_e \cdot [(.6684\ T_b + .1122)/10^3]$
   - Engine material = $W_q^{1/2}T\ N_e \cdot [(10.144\ T_b + 2.126)/10^6]$
4. Maintenance burden = .671 (total direct maintenance)
5. Depreciation expense = $[C_t + .10(C_t - N_eC_e) + .30\ C_eN_e]/15 \div$ trips/year
6. Insurance expense = $[.02\ C_t/U] \cdot T_b$

Indirect Operating Costs

1.	Ground property and equipment	= .683 (aircraft direct maintenance labor)
2.	Aircraft servicing	= .00194 (maximum takeoff gross weight)
3.	Aircraft control	= 65.00
4.	Baggage and cargo handling	= 71.25 (tons of mail, express, and freight)
5.	Freight expense	= .012 (ton-miles)
6.	General and administrative	= .064 (direct operating cost minus depreciation plus indirect operating cost equations 1-5)

[†] Inputs are as follows:

T_b = block time

F_b = block fuel

N_e = number of engines

W_e = operating weight empty minus engine weight

W_q = dry weight of one engine

T = engine thrust

C_t = cost of complete airplane including development

C_e = cost of complete engine

U = utilization

Table 2

INPUTS TO AIRLINE OPERATING COST MODEL

Inputs	747F	C5-A
T_b (hours)		
2000[a]	4	4.3
4500	8.5	9.2
1500	3.05	3.3
3500	6.8	7.3
F_b (pounds)		
2000[a]	97,000	98,000
4500	206,000	188,000
1500	74,000	76,000
3500	168,000	160,000
N_e	4	4
W_e (pounds)	303,395	295,864
W_q (pounds)	8,510	7,010
T (pounds)	45,000	41,100
C_t ($ million)	19.7	21.432
C_e (dollars)	800,000	1,128,000
U	3300, 3800, 3900	3300, 3800, 3900
Payload (pounds)		
2000[a]	207,565	220,000
4500	146,400	110,000
1500	207,565	220,000
3500	186,400	165,000
Max gross take-off weight (pounds)	733,000	728,000

SOURCES: C-5A Operational Planning, Lockheed-Georgia Company, Marietta, Georgia, MER 400, July 1967; Boeing 747 General Description, The Boeing Company, Commercial Airplane Division, Everett Branch, Renton, Washington, D6-13915R, April 1968; Aviation Week and Space Technology, Vol. 87, No. 21, November 20, 1967.

[a]Statute miles.

Table 3

C-5A AIRLINE OPERATING COSTS: RAC COST MODEL
($ per trip)

Cost Category	Statute Miles			
	2000	4500	1500	3500
Direct Operating Cost				
Flight crew expense	1,053.50	2,254.00	808.50	1,788.50
Fuel and oil expense	1,757.29	3,371.59	1,362.78	2,869.19
Maintenance expense	1,341.72	2,631.13	1,078.59	2,131.15
Maintenance burden	900.29	1,765.49	723.73	1,430.00
Depreciation expense				
Utilization = 3300	2,128.00	4,546.00	1,632.00	3,610.00
= 3800	1,847.00	3,951.00	1,417.00	3,132.00
= 3900	1,799.00	3,850.00	1,381.00	3,055.00
Insurance expense				
Utilization = 3300	558.53	1,194.99	428.64	948.20
= 3800	485.04	1,037.76	372.24	823.44
= 3900	472.61	1,011.17	362.70	802.34
Total				
Utilization = 3300	7,739.33	15,763.20	6,034.24	12,777.04
= 3800	7,384.84	15,010.97	5,762.84	12,174.28
= 3900	7,324.41	14,883.38	5,717.30	12,076.18
Indirect Operating Cost				
Ground property and equipment	323.85	620.25	263.36	505.31
Aircraft servicing	1,412.32	1,412.32	1,412.32	1,412.32
Aircraft control	65.00	65.00	65.00	65.00
Baggage and cargo handling	7,837.50	3,918.75	7,837.50	5,878.13
Freight expense	2,640.00	2,970.00	1,980.00	3,465.00
General and administrative[a]				
Utilization = 3300	976.00	1,102.95	894.75	1,007.41
= 3800	971.30	1,092.88	891.14	999.43
= 3900	970.50	1,091.18	890.53	998.08
General and administrative[b]				
Utilization = 3300	1,144.96	1,293.03	1,021.47	1,229.17
= 3800	1,140.26	1,282.96	1,017.86	1,221.19
= 3900	1,139.46	1,281.26	1,017.25	1,219.84
Total indirect operating cost[a]				
Utilization = 3300	10,614.67	7,119.27	10,472.93	8,868.17
= 3800	10,609.97	7,109.20	10,469.32	8,860.19
= 3900	10,609.17	7,107.50	10,468.71	8,858.84
Total indirect operating cost[b]				
Utilization = 3300	13,423.63	10,279.35	12,579.65	12,464.93
= 3800	13,418.93	10,269.28	12,576.04	12,456.95
= 3900	13,418.13	10,267.58	12,575.43	12,455.60
Grand Total				
Total[a]				
Utilization = 3300	18,354.00	22,882.47	16,507.17	21,645.21
= 3800	17,994.81	22,120.17	16,232.16	21,034.47
= 3900	17,933.58	21,990.88	16,186.01	20,935.02
Total[b]				
Utilization = 3300	21,162.96	26,042.55	18,613.89	25,241.97
= 3800	20,803.77	25,280.25	18,338.88	24,631.24
= 3900	20,742.54	25,150.96	18,292.73	24,531.78

NOTE: Airline costs of the C-5A in MAC operations do not include freight expenses because these cover advertising and commissions that do not apply to MAC charters.

[a]Without freight expense.

[b]With freight expense.

Table 4

747 AIRLINE OPERATING COSTS: RAC COST MODEL
($ per trip)

Cost Category	Statute Miles 2000	4500	1500	3500
Direct Operating Cost				
Flight crew expense	980.00	2,082.50	747.25	1,666.00
Fuel and oil expense	1,739.00	3,693.64	1,326.84	3,012.23
Maintenance expense	1,425.40	2,779.41	1,139.55	2,267.89
Maintenance burden	956.43	1,864.98	764.64	1,521.75
Depreciation expense				
Utilization = 3300	1,802.00	3,830.00	1,374.00	3,064.00
= 3800	1,565.00	3,326.00	1,194.00	2,661.00
= 3900	1,525.00	3,241.00	1,163.00	2,593.00
Insurance expense				
Utilization = 3300	477.56	1,014.82	364.14	811.85
= 3800	414.72	881.28	316.22	705.02
= 3900	404.12	858.76	308.14	687.00
Total				
Utilization = 3300	7,380.39	15,265.35	5,716.42	12,343.72
= 3800	7,080.55	14,627.81	5,488.50	11,833.89
= 3900	7,029.95	14,520.29	5,449.42	11,747.87
Indirect Operating Cost				
Ground property and equipment	329.98	626.92	267.30	514.74
Aircraft servicing	1,422.00	1,422.00	1,422.00	1,422.00
Aircraft control	65.00	65.00	65.00	65.00
Baggage and cargo handling	7,394.50	5,215.50	7,394.50	6,640.50
Freight expense	2,490.78	3,952.80	1,868.09	3,914.40
General and administrative				
Utilization = 3300	1,105.96	1,453.92	983.00	1,397.53
= 3800	1,101.94	1,445.38	979.93	1,390.69
= 3900	1,101.26	1,443.94	979.41	1,389.54
Total				
Utilization = 3300	12,808.22	12,736.14	11,999.89	13,954.17
= 3800	12,804.20	12,727.60	11,996.82	13,947.33
= 3900	12,803.52	12,726.16	11,996.30	13,946.18
Grand Total				
Utilization = 3300	20,188.61	28,001.49	17,716.31	26,297.89
= 3800	19,884.75	27,355.41	17,485.32	25,781.22
= 3900	19,833.47	27,246.45	17,445.72	25,694.05

Table 5

RAND COST MODEL[a]
(In $ thousand)

Cost Category	Equation	Source	Remarks
Modification and recurring AGE cost	$V = A_1(A_2 + A_5)(.01)$	(1)	
Petroleum, Oil, and Lubricants	$P = A_3A_2(.342)$	(1)	
Depot maintenance	$D = A_3A_2(.313)$	(1)	
Annual replacement spares	$F = A_3A_2(.208)$	(1)	
Operational personnel per aircraft	$O = A_4(6)(1.057)$	(2)	Six crew members.
		(3) (4)	Crew overhead factor of 1.057; this equals authorized squadron strength minus UE aircraft per squadron times crew members times crew ratio, all divided by UE aircraft per squadron times crew ratio times crew members.
Maintenance personnel per aircraft	$M = [24(1.06)\ A_3]/1008$	(5)	24 maintenance man-hours per fly hr.
		(6)	1.06 maintenance overhead factor.
		(5)	1008 annual direct labor hours of a maintenance worker.
Administrative personnel per aircraft	$B = .17(O + M + 11)$	Note b, source 7	17% is based on Dover AFB manning. 11 members in aerial port squadron per aircraft; the number comes from strengths at Dover and Charleston. Squadron personnel are assumed a function of number of assigned aircraft rather than flying hours.
Support personnel per aircraft	$S = .33(B + O + M + 11)$	Dover & Charleston	
Nonrated officers per aircraft	$C = .9(.01M + .15B + .05S + .22)$	Charleston, Dover, & Travis	.22 men per aircraft: aerial port squadron.
Nonrated enlisted personnel per acft	$E = (.73M + .61B + .61S + 8.14)$	Charleston, Dover, & Travis	8.14 men per aircraft: aerial port squadron.
Rated officers per aircraft	$G = .5(O) + (.1/.9)\ C$	(3)	
Enlisted crew members per aircraft	$H = .5O$	(3)	
Civilians per aircraft	$I = .26M + .24B + .34S + 2.64$	Charleston, Dover, & Travis	2.64 men per aircraft: aerial port squadron. No retirement allowed for civilian personnel. This is small compared with military fringe benefits.
Nonrated officers	$b = C\ A_2$		
Nonrated enlisted personnel	$c = E\ A_2$		
Rated officers	$d = G\ A_2$		
Rated enlisted personnel	$e = H\ A_2$		
Civilian strength	$f = I\ A_2$		
Nonrated officer cost	$J = 10.809(b)(1.25)$	(6)	J-N contains additional 25% for retirement and fringe benefits.
Rated officer cost	$K = 13.254(d)(1.25)$	(6)	
Nonrated enlisted personnel cost	$L = 4.817(c)(1.25)$	(6)	
Rated enlisted personnel cost	$N = 5.882(e)(1.25)$	(6)	
Civilian cost	$Q = 8.117(f)$	(6)	
Total military personnel	$\ell = b + c + d + e$		
Vehicle and other base maint equip	$T = .235\ell$	(8)	
Nonweapon system ops and maint	$U = 1.250\ell$	(8)	
Total personnel cost	$Y = J + K + L + N + Q$		
Total annual operating cost	$a = V + P + D + F + Y + T + U$		
Total operations personnel	$g = (O + 11)\ A_2$		This step puts aerial port squadron personnel with operational personnel.
Total maintenance personnel	$h = M\ A_2$		
Total administrative personnel	$j = B\ A_2$		
Total support personnel	$k = S\ A_2$		
Total ann operating cost per fly hr	$x = a/A_2A_3$		

SOURCES:
(1) Hq USAF, Director's Budget, Cost Division.
(2) USAF Aircraft/Missile Characteristics Summary, Air Force Guide Number One (Black Book), October 1967.
(3) PM 70-1, USAF Program, Manpower and Organization, Vol. 1, Regular Forces, March 1968.
(4) PG 70-2, USAF Program, April 1968.
(5) USAF, AFM 26-3, Criteria and Standards, 26-3M "Mission Equipment Maintenance," 31 March 1967.
(6) Unpublished RAND study.
(7) Dover, Charleston, and Travis Air Force Base manning figures.
(8) Air Force Deputy Chief of Staff, Programming and Operations, Directorate of Studies and Analysis, SWIFT PAIR, A Comparative Analysis of F-12 and F-111 Aircraft in the Interceptor Role, Vol. I, AFXSA-E2-660950, 6 June 1966.

INPUTS:
A_1 = cumulative average cost
A_2 = number of UE aircraft (operationally available aircraft)
A_3 = annual flying hours per UE aircraft
A_4 = crew ratio
A_5 = command support aircraft (not operationally available--reserves and attrition)

[a]Captain Herb Green developed the model.

[b]Manning based on Dover and Charleston as typical bases. Travis is excluded when it seemed that its figures might distort. Travis has an unusually large wing headquarters, and it also has extra activities.

Table 6

C-5A MILITARY OPERATING COSTS: RAND COST MODEL

(In $ thousand/year for 47 UE aircraft)

Item	Case 1	Case 2	Case 3	Case 4
Costs				
Modification and common AGE	10,602.000	10,602.000	10,602.000	10,602.000
POL	25,236.180	30,765.636	38,722.266	42,837.210
Depot maintenance	23,096.270	28,156.854	35,438.799	39,204.815
Replenishment spares	15,348.320	18,711.264	23,550.384	26,053.040
Veh and other base main eqp	911.096	1,079.957	1,323.277	1,449.054
Other support	4,846.254	55,744.454	7,038.706	7,707.733
Pay and allowances	39,281.845	46,656.991	57,286.001	62,780.034
Total annual operating cost	119,321.965	141,717.156	173,961.433	190,633.886
Cost per flying hour	1.617	1.575	1.536	1.522
Personnel Data (Quantity)				
Nonrated officers	157	184	224	245
Nonrated enlisted	1,841	3,341	4,061	4,433
Rated officers	448	545	685	758
Rated enlisted	431	525	660	730
Civilians	1,166	1,375	1,675	1,830
Operations	1,378	1,566	1,837	1,978
Maintenance	1,862	2,270	2,858	3,161
Administrative	551	652	798	874
Support	1,251	1,481	1,813	1,984
Inputs to Model				
Flyaway cost of C-5A ($)	18,600,000	18,600,000	18,600,000	18,600,000
Number of UE aircraft	47	47	47	47
Flying hours per year	1,570	1,914	2,409	2,665
Crew ratio	2.89	3.52	4.43	4.90
Command support aircraft	10	10	10	10

SOURCE: Unpublished RAND documents.

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